UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

BULGE AND LEAKAGE OF THE RUBBER SEALS FOR THE CONTRACTION JOINTS OF THE STEEL-LINED CONCRETE PIPE, SCHEDULE NO. 2, SPECIFICATIONS NO. 2411--SOAP LAKE (INVERTED) SIPHON--WEST CANAL--COLUMBIA BASIN PROJECT

Hydraulic Laboratory Report No. Hyd.-281

RESEARCH AND GEOLOGY DIVISION

BRANCH OF DESIGN AND CONSTRUCTION
DENVER, COLORADO

AUGUST 29, 1950

CONTENTS

FIGURE LIST

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

Branch of Design and Construction
Research and Geology Division
Denver, Colorado
August 29, 1950

Laboratory Report No. Hyd-281
Hydraulic Laboratory
Compiled by: J. G. Norman
Reviewed by: W. C. Case
J. W. Ball

Subject: Bulge and leakage of the rubber seals for the contraction joints of the steel-lined concrete pipe, Schedule No. 2, Specifications No. 2411--Soap Lake (inverted) Siphon--West Canal--Columbia Basin Project

PURPOSE

To determine the amount of bulge and leakage of the above rubber seal when subjected to Soap Lake Siphon head (225 feet) and with 1/2-inch and 1-inch clear openings at the contraction joints of the steel-lined concrete pipe.

CONCLUSIONS

1. The amount of bulge of the rubber seal at 225-foot hydrostatic head, with and without the elastic fillers behind the seal, and at 1/2-inch clear opening at the pipe joint is as follows (see Figures 3 and 8):

Pine wood filler	Self-expanding cork filler per Specifications No. 2411	No filler
0.48 inch	0.74 inch	1.29 inches

The bulge increases to 0.90 inch using the cork filler per Specifications No. 2411 and at hydrostatic head of 370 feet, which was the maximum head for the test equipment. Using the same cork filler, the bulge increased approximately 0.2 inch for all heads after the seal had been subjected to a hydrostatic head of 171 feet for 120 hours (Figure 8).

2. The amount of bulge of the rubber seal at 225 feet of head with a self-expanding type of cork filler (not conforming to Specifications No. 2411) behind the seal and at 1-inch clear pipe joint opening is 1.31 inches (Figure 7).

3. Visual observations disclosed no water leakage attributable to the seal design during any of the tests.

4. If the bulge of the seal is considered excessive, replace the elastic filler with mortar.

INTRODUCTION

This report concerns the rubber seal used at the contraction joints of the steel-lined concrete pipe, Schedule No. 2, Specifications No. 2411, in Soap Lake (inverted) Siphon which is a part of the West Canal in the Columbia Basin Project (Figures 1 and 2). Large expansion joint clear openings existed during the latter stages of construction due to low winter temperatures encountered before the pipe line was earth covered. Also, the pipe line was to be filled with water during the spring of the year. These facts made it probable that the contraction joints would be subjected to Soap Lake Siphon head with clear openings greater than the normal 1/4 inch. Therefore, the Canals Division requested that tests be made to determine the amount of water leakage and seal bulge with clear openings of 1/2 inch and 1 inch at the contraction joints. More emphasis was placed on the 1/2-inch opening since this amount was more representative of opening observed in the field. The rubber seals used in this study represent a section from a typical seal as used in the contraction joints of the 22-foot 4-inch steel-lined pipe line. The maximum head at the lowest point in the siphon is 225 feet of water.

DESCRIPTION OF THE CONTRACTION JOINTS

A section drawing of a contraction joint for the 22-foot 4-inch-diameter steel-lined concrete pipe as used in the Soap Lake Siphon is shown in Figure 3. The joints are made by forming concrete on one side of the joint and allowing it to set before concrete is placed on the other side of the joint. The surface of the concrete first placed at the contraction joint is coated with a sealing compound except the surfaces against which the elastic filler contacts. The seal coat is applied before the concrete on the other side of the joint is placed. The elastic filler is dehydrated cork studded with copper nails. The cork is held securely by the copper nails against the previously placed nonhardened concrete before the concrete on the other side of the joint is placed. The dehydrated cork conforms to Federal Specification HH-F-341, Type II (self-expanding), and it is furnished in strips not less than two feet long. Two rows of 3/4-inch-diameter stud bolts spaced circumferentially on 6-inch centers are tapped and welded to the angles of the steel liner. Clamp plates are of lengths convenient for installation. Open joints between the ends of the clamp plates are 1/4 inch or less. Pneumatically applied mortar is placed in the contraction joints of the steel-lined concrete pipe to the dimensions shown in Figure 3. Convenient lengths of wire mesh are embedded in the mortar.

The rubber seal is a single straight strip 1/2 inch thick by 7-1/2 inches wide. The strip is spliced to form a closed ring at the contraction joint. One-inch diameter holes are either molded or cut on

6-inch centers in two rows, the rows being 4-3/4 inches apart. The holes in the seal are larger in diameter than the 3/4-inch stud bolts to facilitate the installation of the seal in the event of misalignment. The rubber seal is fitted over the 3/4-inch stud bolts and then clamped tight against the joint angles by plates. The rubber seal is fabricated from a high-grade, tread-type compound made of new plantation rubber, reinforcing carbon black, zinc oxide, accelerators, antioxidants, vulcanizing agents, copper inhibitors, and plasticizers, but contains no factice. The compound, according to Specifications No. 2411, shall contain not less than 72 percent by volume of new plantation rubber and has the following physical characteristics. The physical characteristics of the Gates Rubber Company sample, their Compound No. 1564, used in the tests are shown for comparison:

Characteristic	Specifications No. 2411	Gates' sample
Tensile strength, psi, min.	3,300	3,500
Elongation at break, percent, min.	500	500
Shore durometer (Type A)	60 to 70	60 to 70
Specific gravity	1.15 ± 0.03	1.14
Absorption of water, by weight, percent, min.	5	3.7
Compression set (constant deflection) percent of original deflection, max.	30	23
Tensile strength after oxygen bomb aging (48 hours, 70° C, 300 psi) percent of tensile strength before aging, min.	65	80

DESCRIPTION OF THE TEST EQUIPMENT

The test fixture consisted of a pressure-tight steel box of 1/2-inch steel plates whose over-all dimensions were approximately 24 by 14 by 5 inches. The fixture accommodated a full size seal section 20 inches long (Figures 4, 5 and 6). Figure 5 shows a new test sample as well as one in place in the fixture. The fixture was bolted between two cover plates, approximately 28 by 7 by 1/2 inches, to provide greater strength for the higher pressures. End clamps were used to hold the ends of the sample fixed (Figure 5). The 1/2-inch radius on the end of the long leg of the angle iron (Figure 3) near the outside rubber seal surface was omitted on the fixture because flat-parting surfaces were required to seal the end clamps. If no slippage took place between the seal and the contraction joint clamp plates, the amount of clear opening at the joint would represent the amount of stretch in the rubber seal. However, during these tests, slippage did appear to take place between the seal and clamp plates, and, therefore, the seal was stretched less than the amount of the clear opening. The fixture was designed to test the seal at clear contraction joint openings of 1/2 inch and 1 inch (Figure 6). This was

done by providing two sets of end clamps and two sets of screw holes in the top plate and side plates; the holes for the position not in use were plugged. A hand pump was utilized to deliver the hydrostatic head to the seal, and the head was measured by a Bourdon pressure gage. Three needle valves were placed in series in the supply line to insure against leakage which would prevent holding the pressure constant for long periods. A petcock was placed in the line to relieve the pressure when desired. The elastic filler was held in place by three steel brackets and a steel angle plate.

TEST PROCEDURE AND RESULTS

A 20-inch length of the rubber seal had 1-inch diameter holes cut in it for the clamp plate 3/4-inch diameter stud bolts. The seal was placed over the stud bolts with the bolts centered in the holes in the seal. The seal was then clamped tight between the clamp plates. No fixed torque was applied to the nuts of the 3/4-inch bolts since the torque is not specified for field installation. The seal was then stretched to correspond to the desired clear opening at the contraction joint; the end clamps and cover plates were installed and hydrostatic head was delivered to the pressure compartment by the hand pump (Figure 6). The head was increased from zero to 110 psi (254 feet of water), which is in excess of the Soap Lake Siphon head of 225 feet (98 psi). The amount of bulge at the center of the test sample was measured with a depth gage after each increase in pressure of 10 psi (23.1-foot head). The results were plotted to show the amount of seal bulge versus head of water. It should be noted that a decrease in the thickness of the seal occurs with stretching. This decrease in thickness allows the seal to slip between the clamp plates until the seal is restrained by the 3/4-inch stud bolts. This slippage can be slightly more than 1/4 inch with good alignment at the contraction joints because of the difference in the diameters of the 3/4-inch stud bolts and the 1-inch holes in the seal. This means that the amount of stretch in the seal in most cases will be approximately 1/4 inch less than the clear opening at the joint. When the pressure was removed and the clear opening reduced to zero, the seal did not return to its initial position after the clamp plate-seal slippage had occurred, and the seal retained a slight bulge.

In the first test, the amount of seal bulge with a 1-inch clear opening at the contraction joint was determined. The cork filler used in this test was of a self-expanding type but did not conform to Specifications No. 2411 since the latter was not available at the time. The bulge at the Soap Lake Siphon head (225 feet) was 1.31 inches (Figure 7). A filler conforming to Specifications No. 2411 was obtained and used in all subsequent tests except for a test using a pine wood filler.

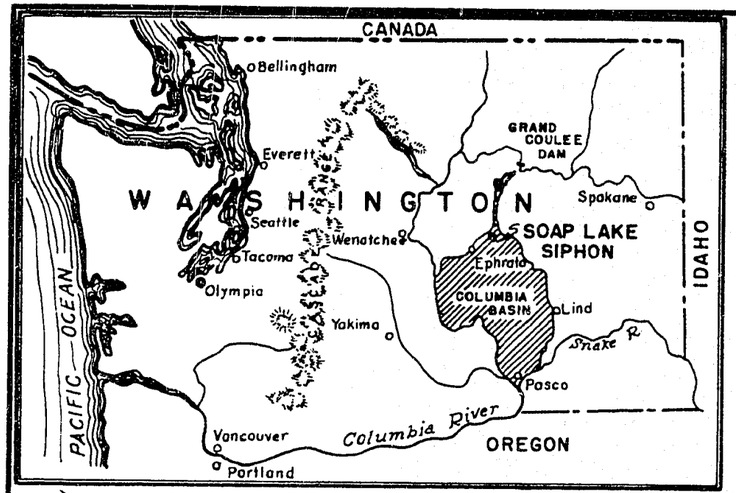
The bulge for a clear opening at the contraction joint of 1/2 inch, using the filler required by Specifications No. 2411, was 0.74 inch at the Soap Lake Siphon head, 225 feet (Figure 8). With the same fixture assembly the seal was subjected to a hydrostatic head of 171 feet (74 psi)

for a period of 120 hours. The bulge of the seal increased approximately 0.1 inch during the 120 hours. After the seal had been subjected to the 74 psi for 120 hours, the bulge versus head was again measured. A oulge increase of 0.20 inch resulted throughout the head range. The bulge at the Soap Lake Siphon head increased from 0.74 to 0.95 inch. The seal bulge over year's of time may become excessive even at clear joint openings of less than 1/2 inch.

A test was also conducted with the elastic filler removed. This was done to give some indication of the amount of restraint offered to bulge by the elastic filler. The bulge at the Soap Lake Siphon head increased from 0.74 inch with the cork filler to 1.27 inches without the filler.

For the final test, the seal was subjected to a hydrostatic head of 370 feet (160 psi), the maximum with the equipment, and using the cork filler per Specifications No. 2411. The bulge at this pressure was 0.91 inches. Visual observations disclosed no appreciable water leakage during any of the tests around the 3/4-inch stud bolts used to clamp the seal.

KEY MAP

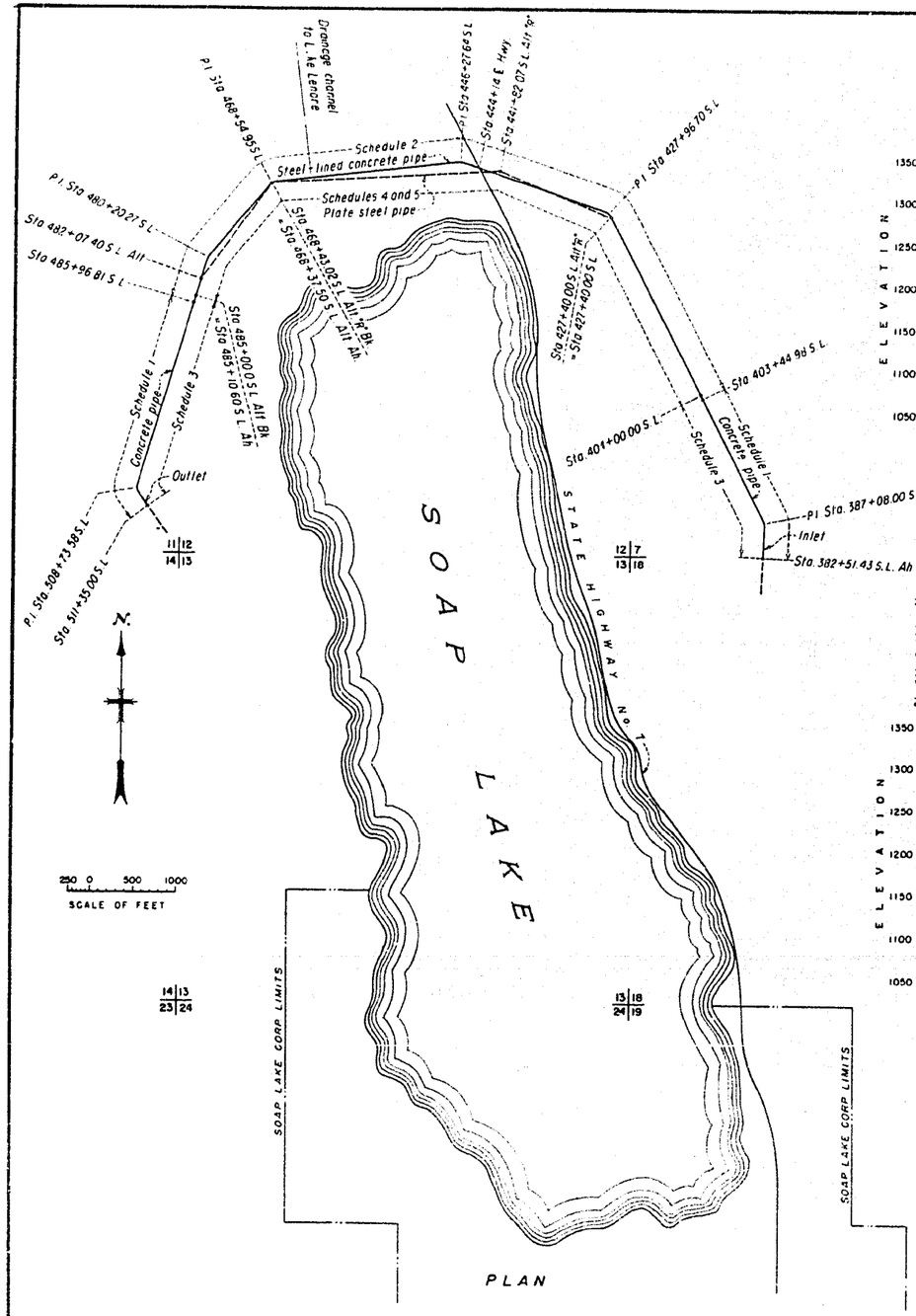


UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLUMBIA BASIN PROJECT - WASHINGTON
WEST CANAL-STA.382+51.43 S.L. Ah TO STA.511+35.00 S.L.
SOAP LAKE SIPHON LOCATION MAP

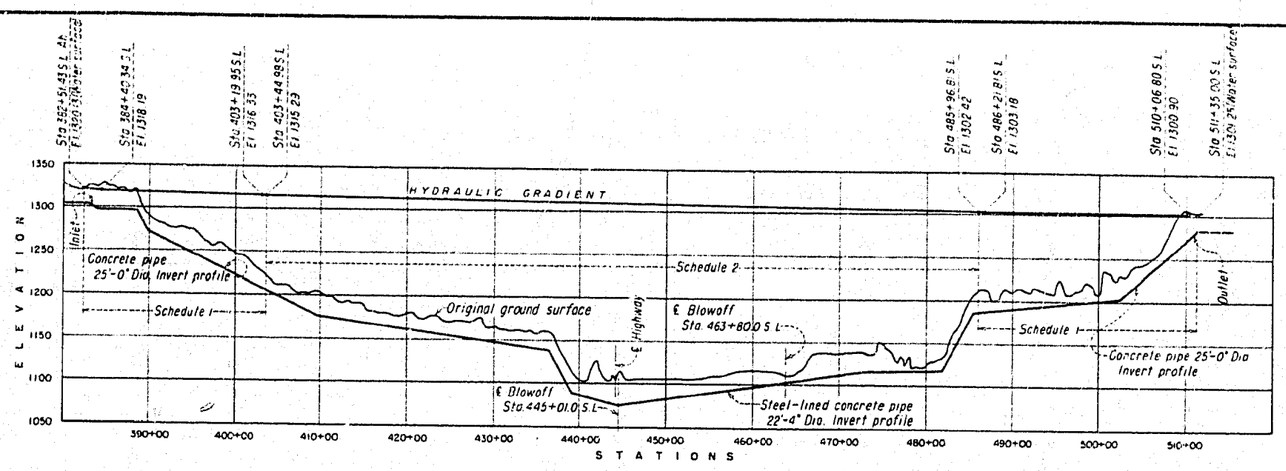
DRAWN RRR. SUBMITTED
TRACED WRK. RECOMMENDED
CHECKED RNC APPROVED

REV. 4-3-47

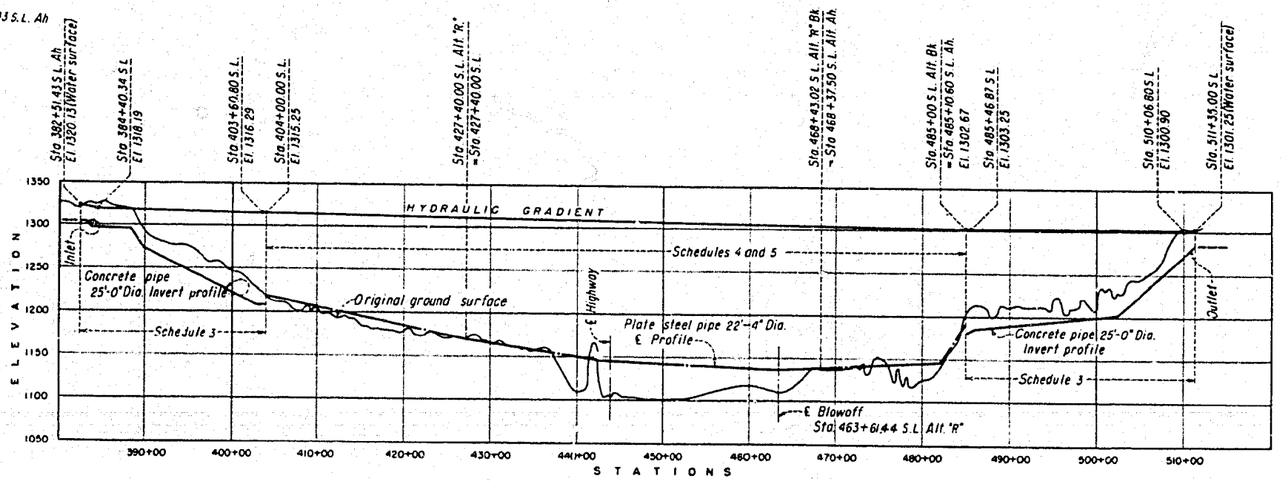
222-P-6473 | EPHRATA, WASH. NOV. 26, 1946 | 222-D-11636



PLAN



PROFILE
CONCRETE AND STEEL-LINED CONCRETE PIPE



PROFILE
CONCRETE AND PLATE STEEL PIPE

SYMBOLS

S L – Soap Lake Siphon Line
S L Alt – Soap Lake Siphon, Alternate Line
S L. Alt "R" – Soap Lake Siphon, Alternate Line, Revised

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLUMBIA BASIN PROJECT – WASHINGTON

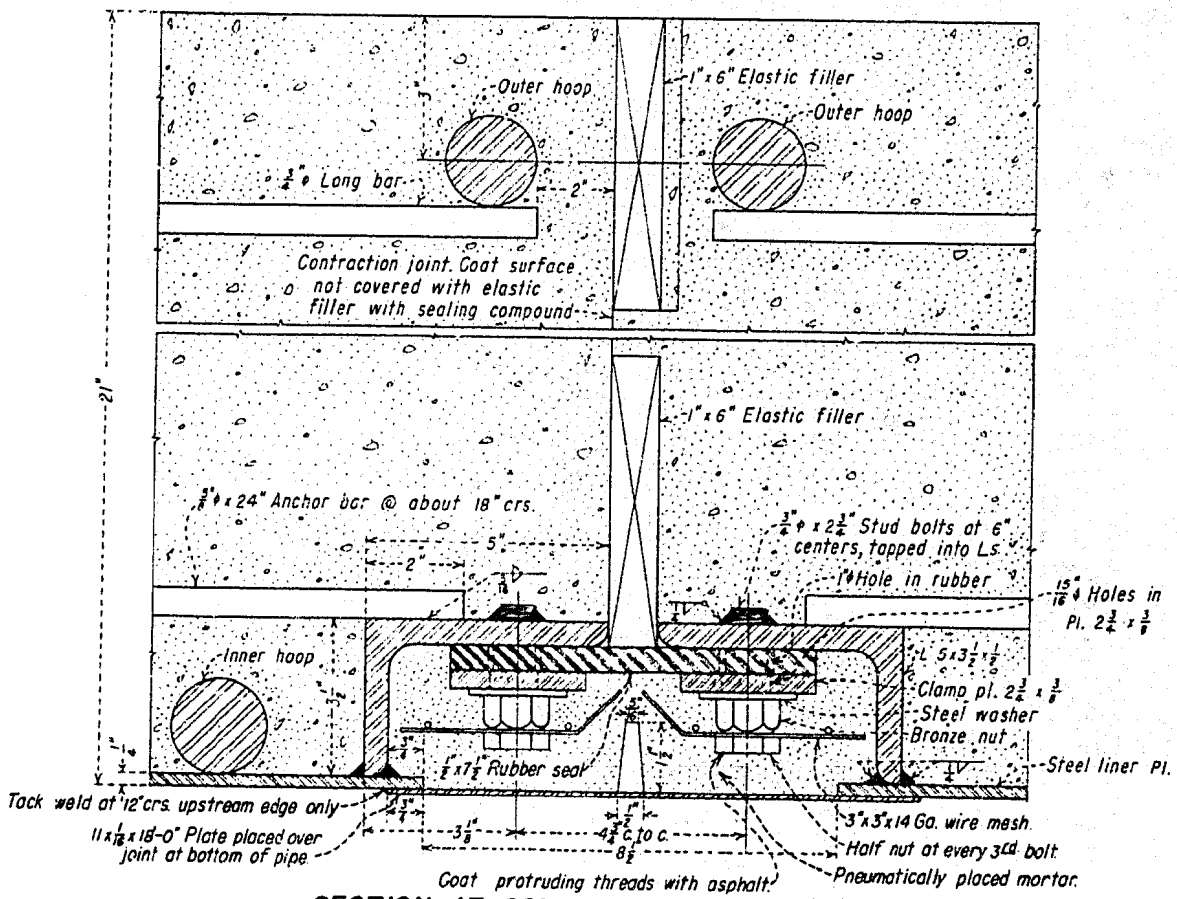
WEST CANAL STA. 382+51.43 S.L. Ab. TO STA. 511+38.00 S.L.

SOAP LAKE SIPHON
GENERAL PLAN AND PROFILES

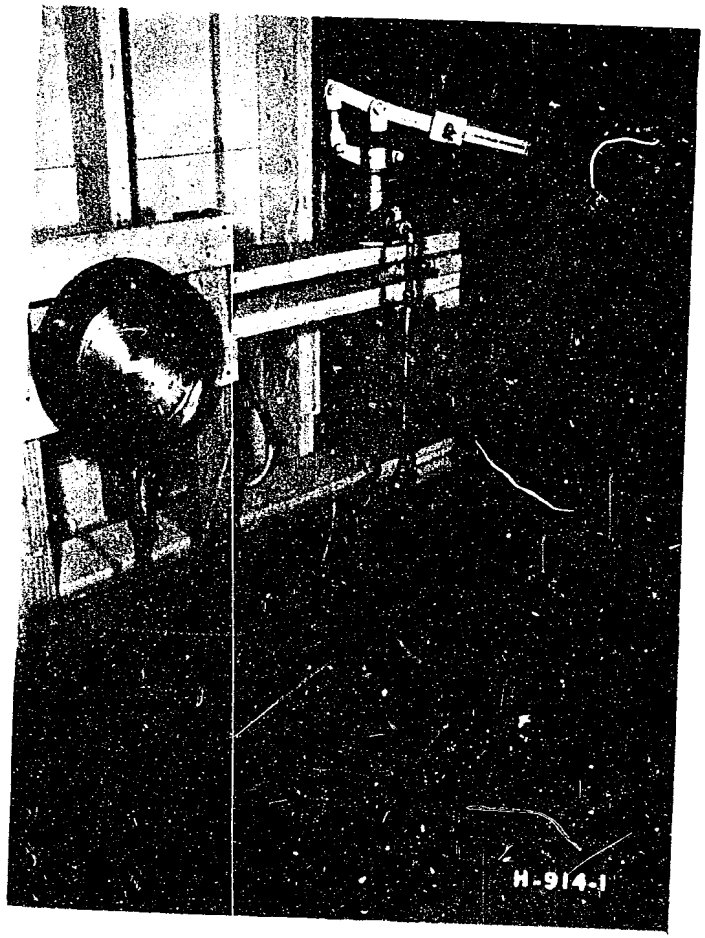
DRAWN W.R.N. SUBMITTED D. Taylor
TRACED I.P. RECOMMENDED J.L. McKinney
CHECKED J.E.W. E.C.C. P.S. APPROVED W.H. Holden
CHIEF ENGINEER

DENVER, COLORADO APRIL 3, 1947 222-D-11537

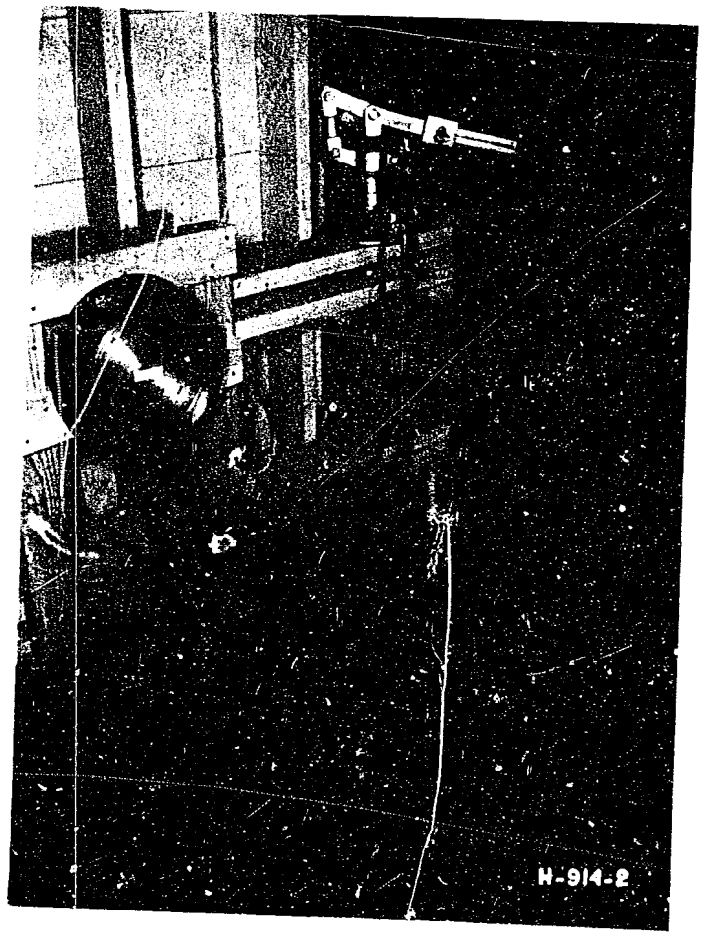
Figure 3
Report Hyd. 281



Columbia Basin Project--Washington
SOAP LAKE SIPHON--CONTRACTION JOINT
Section at a Contraction Joint



A. Overall View with Cork Filler Removed

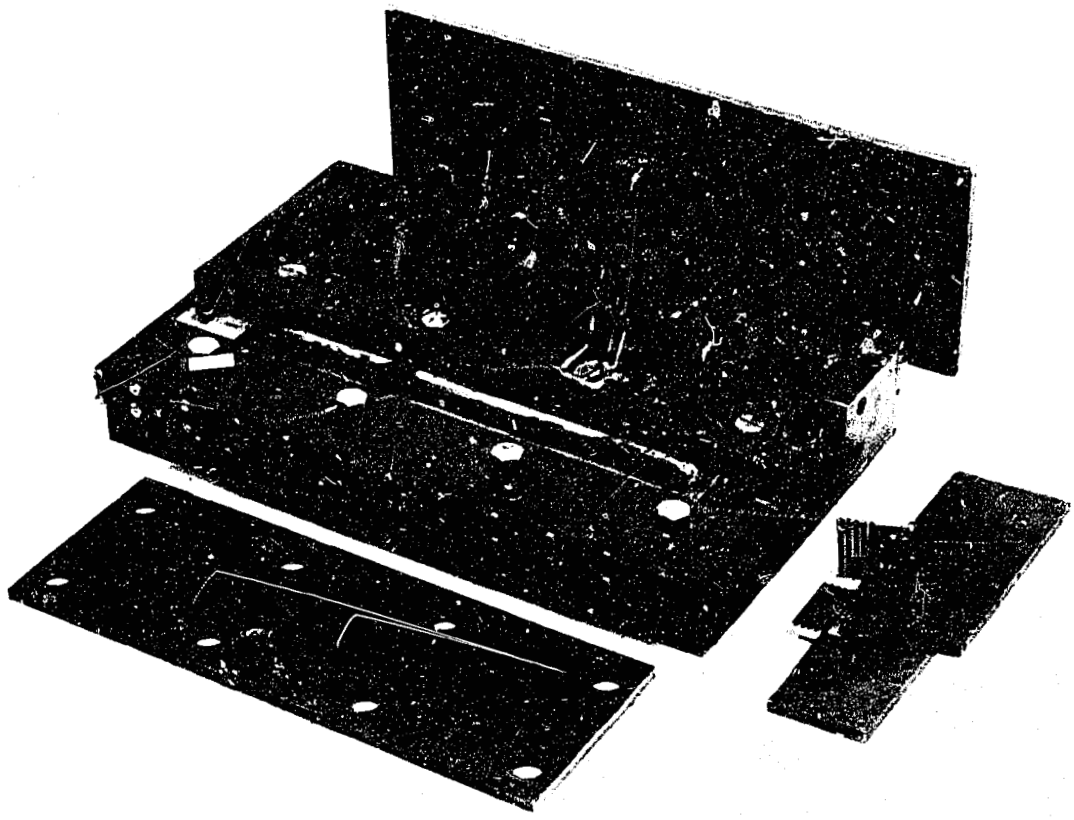


B. Overall View with Cork Filler in Place

COLUMBIA BASIN PROJECT-WASHINGTON
SOAP LAKE SIPHON-CONTRACTION JOINT
General Views of the Test Fixture

Figure 4
Report Hyd.-281

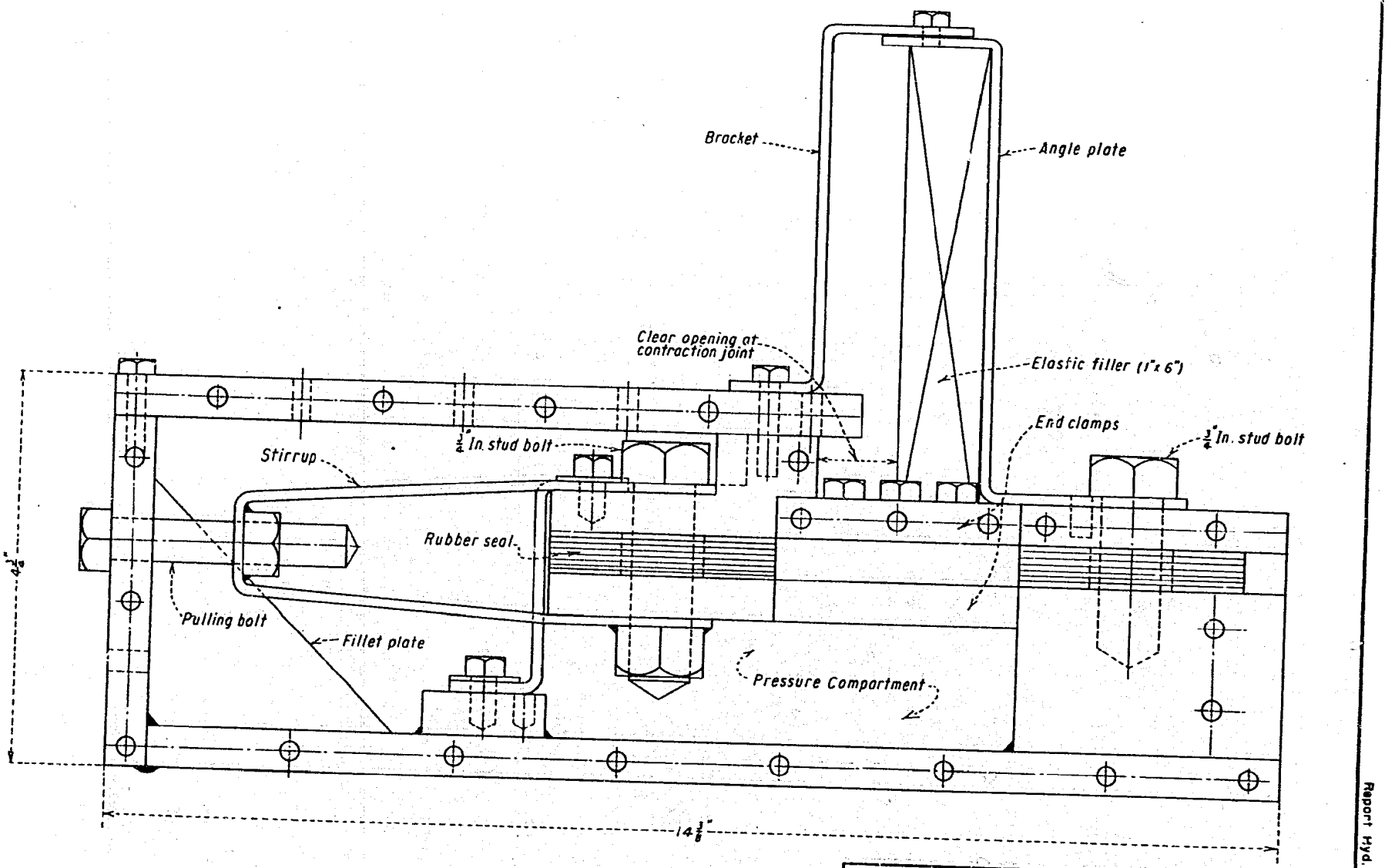
Figure 5
Report Hyd.-281



Columbia Basin Project--Washington

SOAP LAKE SIPHON--CONTRACTION JOINT

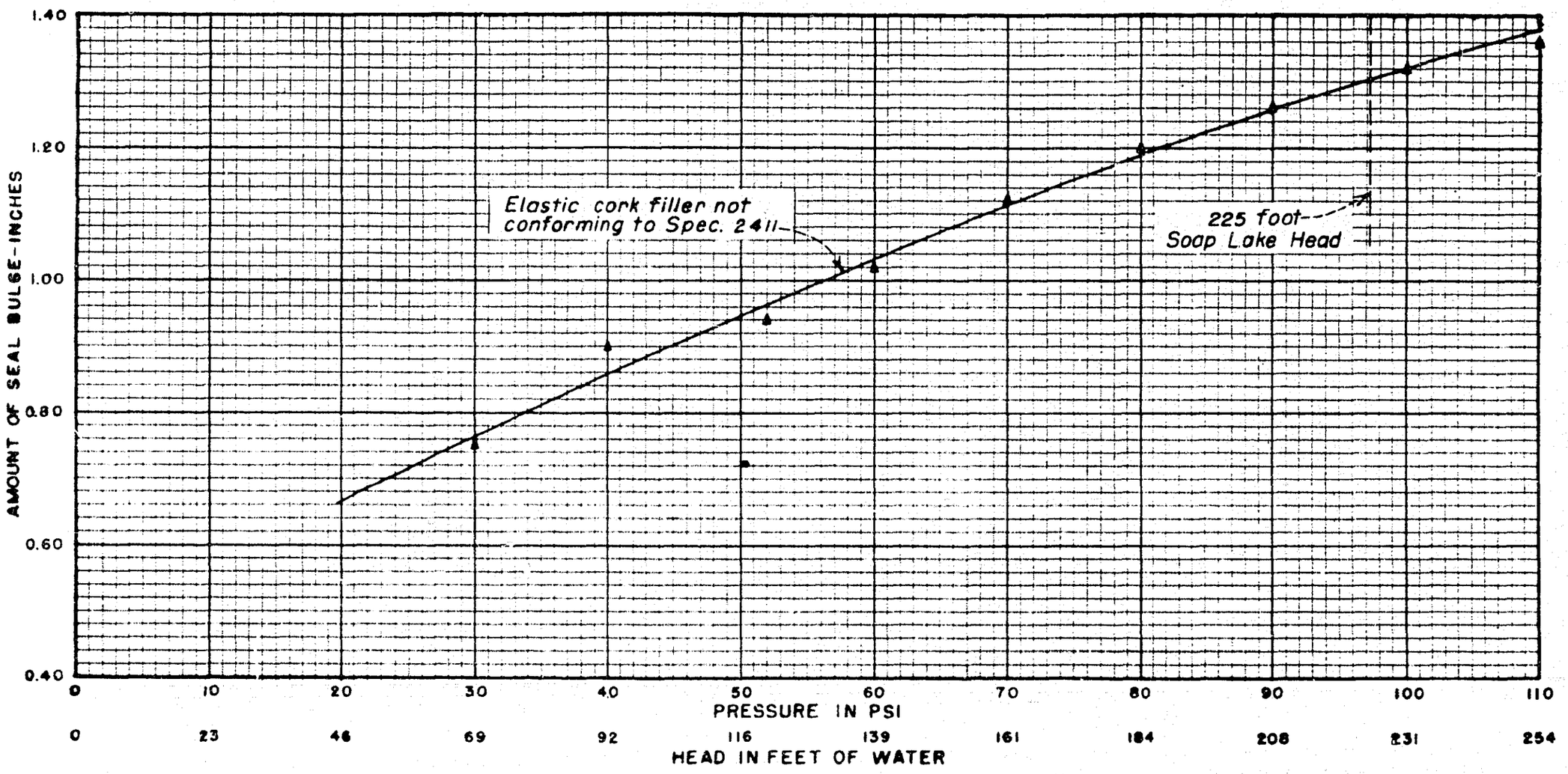
Dismantled View of Test Fixture



END VIEW
END PLATE REMOVED

COLUMBIA BASIN PROJECT – WASHINGTON
SOAP LAKE SIPHON — CONTRACTION JOINT
TEST FIXTURE – END VIEW

Report Hyd. 281 FIG. 6

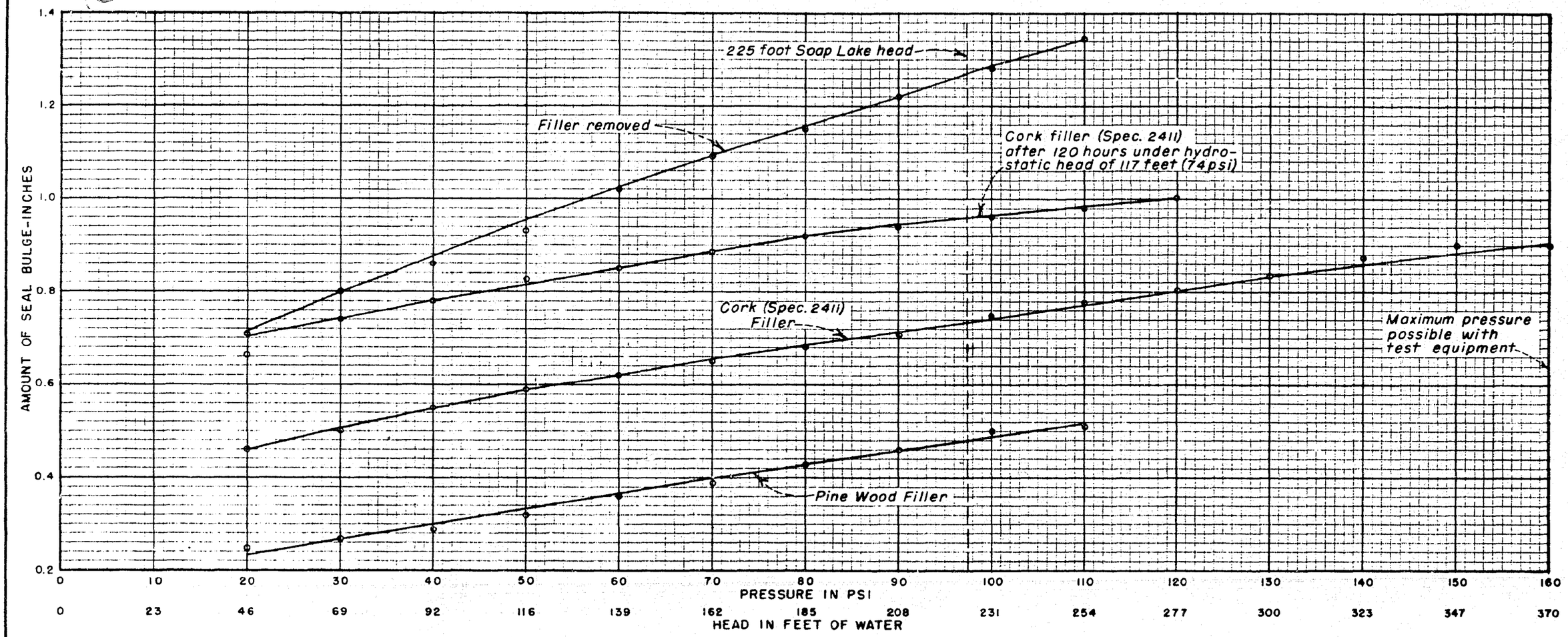


COLUMBIA BASIN PROJECT – WASHINGTON

SOAP LAKE SIPHON – CONTRACTION JOINT

HYDROSTATIC HEAD VS BULGE OF SEAL

FOR ONE INCH CLEAR OPENING AT CONTRACTION JOINT OF STEEL-LINED CONCRETE PIPE



COLUMBIA BASIN PROJECT- WASHINGTON

SOAP LAKE SIPHON - CONTRACTION JOINT

HYDROSTATIC HEAD VS BULGE OF SEAL

FOR ONE-HALF INCH CLEAR OPENING AT CONTRACTION JOINT OF STEEL-LINED CONCRETE PIPE

Interior - Reclamation - Denver, Colo.